

**Table 1.** Summary of studies that found fitness differences between hatchery and naturally produced salmon

Study	Species	Traits	Genetic basis?	Summary
Berejikian, B.A. 1995. The effects of hatchery and wild ancestry and experience on the relative ability of steelhead trout fry ( <i>Oncorhynchus mykiss</i> ) to avoid a benthic predator. Can. J. Fish. Aquat. Sci. 52:2476-2482.	steelhead	predator avoidance	yes	This study describes experiments to quantitatively measure the predator avoidance abilities of wild and hatchery raised steelhead juveniles. Wild and hatchery steelhead native to the same watershed were spawned in a common environment, and the resulting progeny were used in the experiment. The hatchery fish used had been in culture for at least one and up to seven generations. Using three different types of experimental design, the author found that the hatchery juveniles were eaten by a native predator ( <i>Cottus asper</i> ) at significantly higher rates than the wild juveniles. Because both groups were spawned and raised under identical conditions, the author concluded that the observed differences were genetically based.
Berejikian, B.A., Tezak, E.P., Schroder, S.L., Knudsen, C.M. and J.J. Hard. 1997. Reproductive behavioral interactions between wild and captively reared coho salmon ( <i>Oncorhynchus kisutch</i> ). J. Marine Sci. 54: 1040-1050.	coho	mating behavior, fitness (number of progeny produced)	unknown but probably not	Describes the results of a quantitative study of the reproductive behavior of wild and captively reared coho salmon in semi-natural stream setting. The captively reared fish were collected as naturally produced fry and reared to adulthood in captivity. The wild fish were collected as adults from a nearby stream. The captively reared fish did successfully spawn, but the wild spawners were competitively superior, with wild males dominant in 86% of the spawnings. Captively reared females produced on average 62.5% as many nests as wild females. Captively reared fish differed from wild fish in morphology and coloration. The differences between the captively reared and wild fish were probably predominately due to environmental effects, since the captively reared fish were in an artificial environment for less than one generation.

Study	Species	Traits	Genetic basis?	Summary
<p>Chilcote, M.W., Leider, S.A. and J.J. Loch. 1986. Differential reproductive success of hatchery and wild summer-run steelhead under natural conditions. Trans. Am. Fish. Soc. 115:726-735.</p> <p>Leider, S.A., Hulett, P.A., Loch, J.J. and M.W. Chilcote. 1990. Electrophoretic comparison of the reproductive success of naturally spawning transplanted and wild steelhead trout through the returning adult stage. Aquaculture 88:239-252.</p>	steelhead	fitness (proportion progeny produced)	unknown	Both papers describe the contribution of genetically 'marked' steelhead to natural production in the Kalama River and found that naturally spawning hatchery fish were ~30% as successful as wild fish at producing smolts and ~10% as successful at producing returning adults. The hatchery stock used in the experiment was of mixed origin and not native to the Kalama River, and had been in artificial culture for four or five generations with some level of artificial selection occurring during part of that time.
Fleming, I.A. and M.R. Gross. 1989. Evolution of adult female life history and morphology in a Pacific salmon (coho: <i>Oncorhynchus kisutch</i> ). Evolution 43:141-157.	coho	morphology	unknown	Studied body morphology, egg morphology and fecundity of female coho salmon from 13 wild and five hatchery populations and tested a number of a priori predictions relating morphology and fecundity to a number of environmental factors. Found that body and egg morphology differed significantly among populations in the manner predicted by the authors' adaptationist hypotheses. The sampled hatchery populations exhibited a reduction in characters associated with breeding competition and an increase in egg size compared to the sampled wild populations.
<p>Fleming, I.A. and M.R. Gross. 1992. Reproductive behavior of hatchery and wild coho salmon (<i>Oncorhynchus kisutch</i>): does it differ? Aquaculture 103:101-121.</p> <p>Fleming, I.A. and M.R. Gross. 1993. Breeding success of hatchery and wild coho salmon (<i>Oncorhynchus kisutch</i>) in competition. Ecological Applications 3:230-245.</p> <p>Fleming, I.A. and M.R. Gross. 1994. Breeding competition in a Pacific salmon (coho: <i>Oncorhynchus kisutch</i>): Measures of natural and sexual selection. Evolution 48:637-657.</p>	coho	mating behavior, morphology	unknown	In this series of papers the authors described the results of experiments that utilized an experimental spawning channel to study how the reproductive success and behavior of coho salmon is related to a number of variables including morphology, density and origin (hatchery versus wild). The authors found evidence of strong selection at high densities for larger body size and against hatchery origin, and suggest that the behavior of the hatchery fish led to their poor reproductive success. Selection for all traits was stronger at high densities than at low densities, and at low densities hatchery fish performed about as well as wild fish. The hatchery stock had been founded from a local wild stock and had been in culture with no directed program of artificial selection for four generations (12 years).

Study	Species	Traits	Genetic basis?	Summary
Fleming, I.A., Jonsson, B., Gross, M.R., and A. Lamberg. 1996. An experimental study of the reproductive behavior and success of farmed and wild Atlantic salmon. <i>J. Applied Ecology</i> 33: 893-905.	Atlantic salmon			Describes experiments to measure reproductive success and behavior of fifth-generation farmed Atlantic salmon compared to newly captured wild salmon in artificial spawning channels. Farmed females exhibited poor breeding behavior, and had less than a third of the reproductive success of wild females. Farmed males exhibited very poor breeding behavior, and had one to three percent of the reproductive success of wild males.
Kallio-Nyberg, I., and M.-L. Koljonen. 1997. The genetic consequence of hatchery-rearing on life-history traits of Atlantic salmon ( <i>Salmo salar</i> L.): a comparative analysis of sea-ranched salmon with wild and reared parents. <i>Aquaculture</i> 153:207-224.	Atlantic salmon	size, growth rate, age at maturity	yes	Found differences in size, growth rate and age at maturity between first generation hatchery stocks and second and later generations stocks in the Bothnian Bay. Second+ generation hatchery fish grew faster and matured younger. All stocks were reared under identical conditions at the same facility, and originated from nearby rivers.
McGinnity, P., Stone, C., Taggart, J.B., Cooke, D., Cotter, D., Hynes, R., McCamley, C., Cross, T. and A. Ferguson. 1997. Genetic impact of escaped farmed Atlantic salmon ( <i>Salmo salar</i> L.) on native populations: use of DNA profiling to assess freshwater performance of wild, farmed and hybrid progeny in a natural river environment. <i>J. Marine Sci.</i> 54: 998-1008.	Atlantic salmon	fitness (number of progeny produced)	unknown	Used DNA profiling to measure reproductive success of farmed and wild Atlantic salmon in the wild and found that fish-for-fish farmed salmon produced significantly fewer parr and smolts than wild fish. The farmed salmon stock had been in artificial culture for at least six generations.

Study	Species	Traits	Genetic basis?	Summary
Reisenbichler, R.R. and J.D. McIntyre. 1977. Genetic differences in growth and survival of juvenile hatchery and wild steelhead trout, <i>Salmo gairdneri</i> . J. Fish. Res. Board Can. 34:123-128.	steelhead	fitness (survival)	yes	Describes the results of a study in which the progeny of Hatchery x Hatchery, Hatchery x Wild, and Wild x Wild crosses were genetically marked and placed in artificial redds in several tributaries of the Deschutes River, OR. Survival and growth were measured from the eyed-egg to yearling stage, and the progeny of Hatchery x Hatchery crosses were found to have ~80% the survival of Wild x Wild crosses. The opposite pattern was seen in a control hatchery pond. The growth rates also differed significantly among the crosses in some streams, with Hatchery x Wild and Hatchery x Hatchery fish larger than Wild x Wild fish. The hatchery stock used had been founded two generations previously from the same wild stock that was used in the experiment. All matings were performed in the hatchery, so differences in mating success between hatchery and wild fish were not measured. No information was provided on the degree to which the hatchery stock had been artificially selected.
Swain, D.P. and B.E. Riddell. 1990. Variation in agonistic behavior between newly emerged juveniles from hatchery and wild populations of coho salmon, <i>Oncorhynchus kisutch</i> . Can J. Fish. Aquat. Sci. 47:566-571.	coho	juvenile behavior	yes	Quantitatively compared aggressive behavior between wild and hatchery juveniles that had been raised from eggs in a common environment. Hatchery juveniles displayed significantly greater levels of aggression than wild juveniles. The two hatchery stocks used in the study had each been in culture for five generations, and the wild fish were captured in streams near the site of the original hatchery broodstock collections. Because all groups of fish were reared in a common environment, the authors conclude that observed differences were genetically based, and because all the stocks came from the same or nearby populations, the authors conclude that the differences were due to domestication selection in the hatchery rather than differences among the original wild populations. The authors hypothesize that relaxation of selection for predator avoidance in the hatchery was the selective agent.